TECHNOLOGY NEEDS/OPPORTUNITIES STATEMENT

PROVIDE A METHOD TO DEVELOP MASS BALANCE (I.E., HOLISTIC) INVENTORY ESTIMATES

Identification No.: RL-SS40
Date: September 2001

Program: Environmental Restoration
OPS Office/Site: Richland Operations Office/Hanford Site
Operable Unit(s): Broad need potentially applicable to multiple operable units.
PBS No.: RL-SS04 (RL-VZ01)
Waste Stream: Disposition Map Designations: ER-04 [technical risk score 3], ER-14 [technical risk score 5], ER-03 [technical risk score 3]
TSD Title: N/A
Waste Management Unit (if applicable): N/A
Facility: N/A

***Priority Rating*:**

X__ 1. Critical to the success of the ACPC
____ 2. Provides substantial benefit to ACPC projects (e.g., moderate to high lifecycle cost savings or risk reduction, increased likelihood of compliance, increased assurance to avoid schedule delays)
____ 3. Provides opportunities for significant, but lower cost savings or risk reduction, and may reduce uncertainty in ACPC project success.

***Need Title*:** Provide a Method to Develop Mass Balance (i.e., Holistic) Inventory Estimates

Need/Opportunity Category: Technology Need

***Need Description*:** This need addresses specific technical gaps identified in the scope of the Groundwater/Vadose Zone Integration Project (Integration Project) at the Hanford Site and is written as an "integrated" need. The Integration Project is focused on providing the scientific and technical basis to ensure that Hanford Site decisions, including decisions related to long-term stewardship, are defensible and possess an integrated perspective for the protection of water resources, the Columbia River, river-dependent life, and users of the Columbia River resources. As such, this "integrated" need has both applied S&T components that are interrelated in addressing the specified technical gap. Individual efforts applied to resolve the technical gaps described in this need may address all or part of the components identified for this need. Where a specific technology need can be defined separately from an "integrated" need, a specific technology need statement has been written and is included elsewhere in the Hanford Site STCG

Subsurface Contamination Needs (e.g., RL-SS25: Improved, Cost-Effective Methods for Subsurface Access to Support Characterization and Remediation).

Currently, there is not a full inventory data set for all of the contaminants of interest for all of the waste sites of interest at Hanford. These data are needed as input to the SAC which is a suite of tools and data that will be used to assess the cumulative effects of Hanford operations and remediation on the Columbia River and river supported life. Based on scoping studies currently underway within the SAC, key radionuclide and chemical contaminants of most concern for assessing cumulative impacts will be identified. From previous experience, we know there will be gaps in inventory data for many of these contaminants, and that these gaps will contribute significantly to uncertainty in the final assessment.

There is a desire within the stakeholder and Tribal Nation community that all contaminants be included in the inventory model. The purpose of such an exhaustive model would be to ensure that all wastes and all associated impacts would be quantified. It has been suggested that if a specific radionuclide or chemical were not identified as a key contaminant, then it could be lumped with other non-key contaminants and carried throughout the transport and impact estimation process. The non-key contaminants would be represented as a lumped inventory, a lumped transport plume, and a lumped human, ecological, cultural, and socioeconomic consequence. However, once a waste-site specific assessment has been undertaken, the multiple waste types and variety of waste site locations of a Hanford Site assessment make the lumping of inventory, release, transport and impact assessment difficult if not intractable. Consequently, the initial inventory module for the SAC will focus on key radionuclides and chemicals.

The desire of the stakeholder community and Tribal Nations to track all contaminants would be an extension of the initial inventory module and the initial system assessment. Lumping the inventory, its migration and fate, and its impact assessment may not be tractable because of the distributed nature of the multiple-source problem and the desire to represent the uncertainty of disposal on a waste site-by-waste site basis. Clearly, a single simulation could not be conducted and the results scaled for individual waste sites, (e.g., scaled up for some and down for others), to maintain a mass balance of the inventory.

Currently, individual projects use conservative bounding inventory estimates, but use of this approach is not realistic for a site-wide assessment. Use of a conservative or bounding inventory estimate by an individual project can be useful when releases are shown to result in deminimus or low consequences. Projects, (e.g., RPP), are beginning to address a spectrum of inventory issues, (e.g., inventory to be separated into high- and low-level fractions, low-level waste disposal, and the disposal of secondary waste streams from separations and vitrification plants). With these multiple drivers, they too can rely less on a conservative or bounding inventory and need a realistic inventory estimate characterized by a mean and standard deviation. Hence, the primary technical gap is the need to develop a mass balance (i.e., holistic) inventory estimate that results in realistic inventories and estimates of uncertainty. This estimate needs to have a scientifically credible basis such as use of process chemistry and historical records to estimate release quantity, waste chemistry, release location, and time of release from Hanford processes to soil sites.

Specific needs include the following:

– Definition of post-closure Hanford waste site groupings that can be traced to the processes from which wastes were generated and discharged (DOE 1997). These groupings become the basis for developing realistic estimates of waste inventory in the environment over space and time.

– Enhancement of the "Hanford Defined Waste" (HDW) model (Agnew et al. 1997) using process chemistry is needed to estimate the range of probable waste composition, quantities, release locations, and timing of releases. This process chemistry information includes improved partitioning models and tank inventory models (Science Need RL-WT090 and RL-WT091). The process chemistry and tank inventory models are needed by the RPP to support development of pretreatment processes for waste immobilization and disposal. However, radionuclide and chemical partitioning within tank waste will also aid in the determination of soil column inventories, both for planned releases to cribs and trenches and unplanned historical releases (i.e., past leaks). An improved understanding of ^{99}Tc and ^{79}Se, for example, will improve estimates of releases to soils for these contaminants, both of which are important in performance assessments.

– Expansion and enhancement of the HDW model are needed to represent non-tank waste and to identify clearly crib and trench discharges of tank wastes. All past practice liquid discharge sites ready for closure including ponds, cribs, ditches, reverse wells, and specific retention trenches are Environmental Restoration sites (DOE 1999). The chemical separations conducted in the canyon buildings yielded waste streams that were discharged directly to ditches and cooling ponds, chemical sewers, and cribs. Some resulted in significant plumes, (e.g., tritium), that are routinely used for model history matching. Because they were not tank wastes, they are not included in the current HDW model. Additional waste streams and inventories not accounted for in the existing HDW model that need to be added are the Plutonium Finishing Plant (PFP) building, plutonium uranium extraction (PUREX) tunnels, solid waste burial grounds, graphite cores from production reactors, ancillary piping, and residues in the canyon buildings. In addition to these new wastes, the original tank wastes discharged to cribs and trenches and reported in the HDW model need to be identified with specific cribs and trenches instead of being reported as global crib discharges. As in the original HDW model, the revised model shall provide a probabilistic representation of the inventory.

– Determination of ^{79}Se and ^{126}Sn half-lives for which conflicting values have been reported is needed for inventory and system/performance assessment purposes. ^{79}Se is important for long-term protection of the environment. ^{126}Sn is important in the protection of inadvertent intruders. For purposes of the system assessment inventory measurement of the half-lives within +/- 50% is sufficient. Other projects require +/-10%.

– Estimation of released waste inventory and uncertainty for ^{3}H, ^{60}Co, ^{99}Tc, ^{90}Sr, ^{137}Cs, ^{129}I, U, ^{237}Np, Pu, Am, Na, Al, Cr, CCl_4, OH^-, NO_3^-, complexants, pH, density, ionic strength, heat load, water weight %, water vapor pressure, and redox state as needed. This first listing of inventory needs is a result of an initial review of radionuclides and chemicals found to be significant in the assessment of both plateau and near-river waste sites. Coordination with RPP which has a need to estimate uncertainty of Hanford Best Basis toxic waste inventory, concentration, phase and waste type (Technology Need RL-WT070) will be beneficial to multiple projects.

– Specific models for ^{99}Tc, ^{129}I, and tritium need to be established to transition from conservative to mass-balance models of inventory. The ^{99}Tc model is needed to reconcile ^{99}Tc inventory. Consistent with new mass balances being completed by the RPP in FY99. This model must also be able to reconcile inventory problems for ^{99}Tc uncovered from past work such as the Composite Analysis (Kincaid et al 1998), e.g., shipment of ^{99}Tc offsite with uranium and underestimates of ^{99}Tc discharges to cribs receiving wastes from the uranium recovery campaign. Likewise, a model for ^{129}I is needed to reconcile inventory completeness issues discovered from past work on the Composite Analysis. The iodine model is complex because will include aspects of atmospheric emissions, stack scrubbers, scrubber regeneration, scrubber failure, and scrubber disposal. A model for tritium is needed to help in benchmarking the overall inventory model and the overall vadose zone and groundwater models that are essential components of the SAC. Future efforts may uncover additional contaminants for which selected models may be needed and will be added to this need in the future as required.

– An accurate, robust production laboratory method for the measurement of ^{99}Tc concentration in Hanford waste tank matrices and in soils from the vadose zone surrounding the tanks is needed (Technology Need RL-WT01). The method must provide a high level of confidence in the ^{99}TC concentrations because the data is important in risk-based assessments. The development of this method is needed so that data can be obtained to benchmark the process chemistry, release, vadose zone, and groundwater models.

– Characterization methods to determine organic species in tank waste are needed. There are two aspects to this need: 1) The speciation of the organic compounds determines the complexing characteristics of the organic compound. The complexing nature can affect the behavior of other waste components and can affect the mobility of specific components in the waste and in the vadose zone. 2) Measurement of the amount of certain *Resource Conservation and Recovery Act* (RCRA) and *Toxic Substances Control Act of 1976* (TSCA) organic compounds in the waste is important to risk-based assessments.

– Direct methods for inorganic and organic analyses of high level waste would reduce turn-around time, waste production, and worker exposure which would in turn reduce costs. Lower costs for characterization would make it possible to characterize more of the waste tanks and the contaminated zones around and beneath the tanks. The additional data could also be used to improve the benchmarking of the models.

Schedule Requirements:

Earliest Date Required: 8/1/99

Latest Date Required: 9/30/05

The Integration Project S&T roadmap (DOE/RL-98-48, 2000) indicates the information that is required over the next 6 years to meet the objectives of the Integration Project. Information associated with inventories is needed in the FY03 timeframe to meet the objective of the Integration Project to provide the System Assessment Capabilities with updated inventories that capture uncertainties. Such an analysis will not only satisfy the DOE requirement for active and near-term planned disposal and remediation action decisions, but will also inform DOE-Office of River Protection (ORP) on the cumulative impacts of decisions bearing on tank waste recovery and tank residuals.

***Problem Description*:** This need falls under the Inventory Technical Element within the S&T Endeavor. Inventory is defined as the total quantity of radiological and chemical constituents used and created at the Hanford Site, and their distribution in facilities, waste disposal sites, the vadose zone, groundwater, and Columbia River ecosystem. The Inventory Technical Element is intended to address the need for estimates of radionuclide and chemical contaminants that have been or are expected to be released to Hanford's soil column. Such an inventory would represent the total amount of selected radionuclide and chemical constituents at the Hanford Site and their distribution among facilities, waste disposal sites, vadose zone, groundwater, and Columbia River. The objective of the Inventory Technical Element is to enhance protection of human health and environment by providing estimates of the location, amounts, concentrations, chemical form, and mobilization/release mechanisms of key inventory components, which provides the necessary input to site-wide subsurface system assessments. An implicit goal of this research is to provide scientifically defensible knowledge and data and identify existing and new S&T that will serve as input to DOE's decision-making process for Hanford cleanup.

The goals of the inventory technical element are largely twofold. First, a consistent approach and set of assumptions for providing information on waste site inventories across the Hanford Site needs to be established to ensure that a site-wide inventory data set is available for system-wide and project-specific impact assessments. Second, key chemical and radiological contaminants and soil sites need to be identified, and estimates of the amount of these key contaminants in different waste forms and storage/disposal areas (e.g., tanks, solid waste burial grounds, other) need to be validated.

A good understanding of inventory is key to a system assessment, because the potential groundwater and river contamination is proportional to the amount of radionuclides and chemicals that are disposed on Hanford Site and capable of migrating off the Site. Technical information needed to determine inventory include 1) locations, amounts, and concentrations; 2) characteristics of the radionuclide or chemical compound; 3) mobilization and release mechanisms and rates; and 4) the change in inventory because of natural processes (e.g., decay), remediation activities, and Hanford Site operations. In addition to inventory estimates, mechanisms must be identified that result in release of the inventory from facilities into the vadose zone, unconfined aquifer, or the Columbia River. Because the long-term configuration of the waste inventory depends on future remediation and land-use decisions, a baseline estimate of end-state inventory distributions must be defined.

Benefit to the Project Baseline of Filling Need: Completion of a first inventory model based on available data, process chemistry knowledge, and uncertainty principles is essential to any site-wide or system assessment. Currently, there is no single and consistent inventory for the discharges and disposals of radionuclides and chemicals to the surface and subsurface in the 100 B/C, 100 K, 100 N, 100 D, 100 H, 100 F, 300, 200 West and 200 East Areas. This inventory should also provide the basis for investigating existing contamination in the Columbia River by recording the existing knowledge of discharges to the river during the reactor operation period. Successful completion of these activities is required to meet the objectives of the Integration Project and the related elements of the Paths to Closure.

***Functional Performance Requirements*:** The techniques applied or information that is obtained must estimate contaminant inventory such that the information can be applied toward the conceptual models, fate and transport numerical models, site-specific assessments, and system assessment capabilities that are being developed as part of the Integration Project.

Work Breakdown
Structure (WBS) No.* :** 1.4.03.4.4 ***TIP No.: TIP-0015

Relevant PBS Milestone: PBS-MC-042

***Justification For Need*:**

Technical: Currently, there is not a full inventory data set for all of the waste sites and all operational areas at the Hanford Site. This data set is needed as input to the SAC, which is a suite of tools, and data that allow the cumulative effects of Hanford operations and remediation on the Columbia River and associated river supported activities. Previous experience indicates that a lack of a method to provide a realistic estimate of inventory adds substantial (i.e., an order of magnitude) uncertainty in the modeling results (DOE 1999).

Regulatory: Information obtained by addressing this need will provide an improved technical basis for making site regulatory decisions and therefore reduce the uncertainty associated with the basis for these decisions. A site-wide Composite Analysis of all post-closure sources is required every 5 years under DOE Order 5820.2a (and draft DOE Order 435.1). Other site-wide assessments are needed by Environmental Restoration (ER) and RPP to fully understand the nature of competing alternatives (e.g., ER characterization and cleanup versus RPP tank waste recovery and stabilization).

Environmental Safety & Health: This need addresses broad site-wide technical issues and, as such, crosscuts multiple applications that each may have specific environmental safety and health issues. The CRCIA Part 2 (DOE 1998) guidance requires the assessment of human health, ecological health, and cultural and socioeconomic impacts. All of these societal health metrics are impacted by the broad support of stakeholders and Tribal Nations, (e.g., common health exposure and dose scenarios are being adapted to include exposures typical of Native Americans). As these broad metrics are applied, a longer list of radionuclides and chemicals may be revealed as essential to the assessment.

Potential Life-Cycle Cost Savings of Need (in $000s) and Cost Savings Explanation: The estimated life-cycle cost savings associated with filling this need is $200M. This estimate is based on an assumed savings of 5% of the total Hanford remediation life-cycle cost of >$5B. Estimated savings are due to information and data gained by filling this need that supports decisions for cost effective remediation and long-term stewardship.

Cultural/Stakeholder Concerns: This technology need supports the resolution of cultural and stakeholder concerns as expressed by the CRCIA Team in "Columbia River Comprehensive Impact Assessment, Part II: Requirements for a Columbia River Comprehensive Impact Assessment." [Stakeholder and Tribal Nation concerns about the completeness and consistency of the assembly of inventory data and estimates are expressed in the CRCIA Part 2 document (DOE 1998).]

Other: None.

Current Baseline Technology: N/A

End-User: Richland Environmental Restoration Project

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